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**PART II - CONSTRUCTION MATERIALS AND METHODS
SECTION 20**

**EXCAVATION, BEDDING, BACKFILL AND SURFACE RESTORATION FOR
PIPELINES AND UTILITY TRENCHES**

20.1 GENERAL

Piping for newly constructed storm drainage, irrigation lines, sanitary sewers, water systems, service lines and laterals, and other utility lines, to be installed in easements or public right-of-way, under the jurisdiction of the City, shall be excavated, bedded, backfilled and the trench resurfaced in accordance with approved engineered plans, and the City of Arvada "Engineering Code of Standards and Specifications for the Design and Construction of Public Improvements". These Specifications shall apply to all new construction within the City of Arvada.

The Contractor performing the work shall be properly licensed with the City, obtain all permits, and give twenty-four (24) hours written notice to the Engineering Division, setting forth the time construction is to commence or when work is to be resumed following a delay. The Contractor shall maintain a complete set of approved drawings and specifications, covering the work being performed, on the project at all times.

20.2 MATERIALS

Materials, other than pipe and fittings, which are to be placed within the trench limits and below finished grade, shall conform to the minimum standards hereinafter referred to.

Specifications and detailed recommendations for acceptable Practices set forth by the American Society for Testing Materials (ASTM), the American Association of State Highway Transportation Officials (AASHTO) and the Colorado Department of Transportation (CDOT) are made a part of these Specifications.

20.2.1 Foundation Stabilizer Material

3/4" to 1 1/2" dense, durable rock with less than fifteen (15) percent passing the #4 sieve.

20.2.2 Bedding

Free draining material meeting the Specifications and gradation for the specific application set forth as follows:

BEDDING MATERIAL

| BEDDING TYPE | SQUEEGEE₁ | PIPE BEDDING "B"₂ | AGGREGATE₃ | FILLER SAND₄ |
|---------------------|------------------------------------|-------------------------------------|------------------------------|--------------------------------|
| AASHTO Spec. | Local by-product | Local by-product | M-43 | M-6 |
| CDOT Spec. | Local by-product | Local by-product | #67 | |
| SIEVE SIZE | % PASSING SQUARE MESH SIEVE | | | |
| 1 1/2" | | | | |
| 1" | | | 100 | |
| 3/4" | | | 90-100 | |
| 1/2" | | | | |
| 3/8" | 100 | 100 | 20-55 | 100 |
| #4 | 40-90 | 70-100 | 0-10 | 95-100 |
| #8 | | 36-93 | 0-5 | |
| #16 | | 20-82 | | 45-80 |
| #30 | | 8-65 | | |
| #50 | | 2-30 | | 10-30 |
| #100 | | 1-10 | | 2-10 |
| #200 | 0-5 | 0-5 | | |
| P.I. | 0 | | 0 | 0 |
| L.L. | 0 | | 0 | 0 |

- 1 Local Platte River by-product allowed on all sizes and types of conduits
- 2 "Pipe Bedding B" is an acceptable alternative to Squeegee
- 3 May be used in lieu of squeegee on 27" and larger conduits only
- 4 To be used for sewer main casing pipe filler only

20.2.3 Backfill

Soils and soil aggregate mixtures classified in accordance with AASHTO M-145, Table 2, which also meets the categories hereinafter specified.

- A. **SELECT BACKFILL MATERIAL** – to be used for all trenches greater than 50 feet long in all paved streets.

Gravel, Stone Fragments, Sands and Silty Soils

| Group Classification | A-1-a | A-1-b | A-3 | A-2-4 |
|-----------------------------|---------|---------|---------|---------|
| Sieve Analysis % Passing | | | | |
| #10 | 50 Max. | | | |
| #40 | 30 Max. | 50 Max. | 51 Min. | |
| #200 | 15 Max. | 25 Max. | 10 Max. | 35 Max. |
| Characteristics of L.L. | | | | 40 Max. |
| Fractions (-#40 Sieve) P.I. | 6 Max. | 6 Max. | N.P. | 10 Max. |

CDOT Class 1 Structure Backfill Material and Class 6 Road Base Material qualify as Select Backfill Material.

- B. **ACCEPTABLE BACKFILL MATERIAL** – to be used for all trenches in unpaved areas where approved by the Engineer

Silty or Light Clayey Gravel and Sandy and Silty Soils

| Group Classification | A-2-5 | A-4 | A-5 |
|-----------------------------|---------|---------|---------|
| Sieve Analysis - % Passing | | | |
| #200 | 35 Max. | 36 Min. | 36 Min. |
| Characteristics of L.L. | 41 Min. | 40 Max. | 41 Min. |
| Fractions (-#40 Sieve) P.I. | 10 Max. | 10 Max. | 10 Max. |

- C. **UNACCEPTABLE BACKFILL MATERIAL** – to be used for trenches across open fields only where approved by the Engineer

Heavy Clayey Gravel and Silty, Clayey Soils

| Group Classification | A-2-6 | A-2-7 | A-6 | A-7 |
|-----------------------------|---------|---------|---------|---------|
| Sieve Analysis - % Passing | | | | |
| #200 | 35 Max. | 35 Max. | 36 Min. | 36 Min. |
| Characteristics of L.L. | 40 Max. | 41 Min. | 40 Max. | 41 Min. |
| Fractions (-#40 Sieve) P.I. | 11 Min. | 11 Min. | 11 Min. | 11 Min. |

Note: Material in Category C above shall be disposed of and replaced with acceptable backfill material, unless specifically approved in writing by the Engineer for use as backfill.

20.2.4 Flowable Fill/Flowable Fly Ash Backfill

Where required and/or approved by the Engineer and within the top four (4) feet of all paved street cuts less than 40 feet long, and at the expense of the Contractor/Developer, the following materials shall be used in lieu of granular backfill. This material shall also be used for the full depth of all cross trenches within existing streets.

| FLOWABLE FILL | |
|--|---|
| <u>Ingredients</u> | <u>Pounds Per Cubic Yard</u> |
| Cement | 50 |
| Class F Fly Ash | 50 |
| Coarse Aggregate(AASHTO No. 57 or 67) | 1700 |
| Fine Aggregate Sand (AASHTO M6) | 1845 |
| Air Entraining Agent | 5 oz. |
| Water (39 Gallons) | 325 (or as needed for proper consistency) |
| <p>Flow-Fill shall have design compressive strengths of 50 to 150 psi at 28 days, when tested in accordance with ASTM D4832. The Flow-Fill shall be limited to a maximum Removability Modulus (RE, as described below) of 1.5. It shall have an air content of 15% to 21% when tested in accordance with ASTM C231 and a slump in the range of 7 to 10 inches when tested in accordance with ASTM C143. Compaction of flowable fill will not be required if material meeting the above requirements is used.</p> | |

| FLOWABLE FLY ASH BACKFILL | |
|---|---|
| <u>Ingredients</u> | <u>Pounds Per Cubic Yard</u> |
| Class C Fly Ash | 200-400 |
| Class F Fly Ash | 1,600-1,800 |
| Water (96 Gallons) | 800 (or as needed for proper consistency) |
| <p>Fly ash shall meet the requirements of ASTM C618 Type C or Type F. Fly ash not meeting the requirements of ASTM C618 may be used if prior testing indicates acceptable, consistent results for strength and air content. Desired 28 day strength range is between 100 psi and 300 psi. Removability modulus (RE, as described below) not to exceed 1.5. Compaction of flowable fill will not be required if material meeting the above requirements is used.</p> | |

FOAMED FLOWABLE FLY ASH BACKFILL

| <u>Ingredients</u> | <u>Pounds Per Cubic Yard</u> |
|--------------------|---|
| Class C Fly Ash | 732 |
| Class F Fly Ash | 932 |
| Water (96 Gallons) | 699 (or as needed for proper consistency) |
| Cellular Foam | 4.9 CF |

Fly ash shall meet the requirements of ASTM C618 Type C or Type F. Fly ash not meeting the requirements of ASTM C618 may be used if prior testing indicates acceptable, consistent results for strength and air content. Foaming agents shall conform to ASTM C869 and C796, or as approved by the Engineer.

Desired 28 day strength range is between 100 psi and 300 psi when tested in accordance with ASTM D4832. Air content to be between 15% and 21% when tested in accordance with ASTM C231. Slump to be between 8-11 inches when tested in accordance with ASTM C143. Removability modulus not to exceed 1.5 to be calculated as follows:

The Removability Modulus* , RE, is a value calculated by:

$$RE = \frac{W^{1.5} \times 104 \times C^{0.5}}{10^6}$$

W = in-situ unit weight (pcf) and C = 28-day compressive strength

*RE was developed & is used by Hamilton County, Ohio; per the NCHRP #597 CLSM Report. A lower RE indicates material that is easier to excavate or remove.

Compaction of flowable fill will not be required if material meeting the above requirements is used.

20.2.5 Surfacing

See "Concrete" Part II Section 10 and "Hot Bituminous Pavement" Section 11 of these Specifications.

20.3 **CONSTRUCTION PRACTICES**

Prior to excavating in hard surfaced areas, the outer limits of the trench shall be string lined and the surfacing cut in a vertical, straight plane by milling, sawing, roller blade or jack hammering so the joint line between existing and replacement pavement is straight and neat. Drop blades are not acceptable. The cut depth shall be full depth through the existing pavement. Concrete pavement removal shall be full panel at existing joints only. Nominal trench width limits at the surface, which shall be the width used in determining the quantity of resurfacing or patching for payment, shall be three feet plus the outside diameter of the pipe,

unless otherwise called for in the Special Conditions of a City project or approved in writing by the Engineer. During construction, should the vertical asphalt edges ravel, they shall be trued to a vertical plane to a point six (6) inches outside the limits of excavation prior to placing the resurfacing material.

20.3.1 Embankment

Depressed areas where piping is to be installed shall be raised to the proposed crown elevation of the pipe to be installed, prior to excavating the pipe trench. Preparation and placement of fill in low depressed areas shall be performed as set forth under Embankment in Section 5 of these Specifications.

20.3.2 Excavation

The excavation shall be made to lines and grades shown on the plans and as established by the Engineer. All excavation shall be classified as "unclassified" or "rock" excavation only. Excavation shall include materials of every description, and of whatever substance encountered, to the depths and of the areas required for the construction work. All excavation not classified as "rock excavation" as defined below shall be "unclassified". "Unclassified" shall mean no classification will be made of the materials excavated neither as to depth, nature, composition, hardness nor degree of water content.

Surfacing materials such as concrete and asphalt shall be removed to neat lines and disposed of independently of the underlying soil; base course and gravel are to be salvaged to stockpile, protected from contamination and reused for select backfill.

Soils removed from the trench which meet the requirements for backfill materials, shall be stockpiled in a manner which will not endanger the performance of the work, obstruct sidewalks, driveways or gutters and provide the least possible interference with traffic. Soils encountered which are unacceptable for use as backfill shall be disposed of by the Contractor at his expense.

At no time will trench excavation be permitted to advance ahead of the installed pipe in excess of one hundred (100) feet at any one time during the performance of the work.

20.3.2a Rock Excavation

Rock excavation shall consist of igneous, metamorphic and sedimentary rock which cannot be excavated without blasting or the use of rippers, and all boulders or other detached stones each having a volume of one (1) cubic yard or more as determined by physical or visual measurement.

20.3.2b Blasting

Excavation by use of blasting shall be allowed for portions of the work which may be expedited by use of such methods. The Engineer may limit or prevent the use of blasting whenever, in his opinion, the blasting may harm public safety or public or private property. All blasting shall be conducted in accordance with all applicable laws, ordinances and regulations imposed by federal, state and local authorities. All trench walls shall be shored or braced prior to blasting. The Contractor shall be responsible for and take special precautions to prevent damage to all adjacent structures whenever blasting is performed.

20.3.3 Wet Trench

The Contractor shall provide and maintain adequate equipment to properly remove and dispose of all surface or ground water entering the trench. The use of any sanitary sewer

connected to the City effluent lines to dispose of trench water will not be permitted. The trench shall be dry at all times during pipe installation and so maintained until the jointing operation is complete. It is the responsibility of the Contractor to use pipe foundation stabilizer material as necessary to assist him in maintaining a dry trench and stabilizing the trench bottom for pipe installation.

20.3.4 Trench Depth

Where soft unstable soils, dense shale, or rock is encountered at the normal trench bottom, the Contractor shall undercut and dispose of such materials, to the limits established by the Engineer, and backfill the void thus created with pipe foundation stabilizer material.

In dense shale or rock, the undercutting shall be not less than six (6) inches and in unstable soils to not less than twelve (12) inches below the bottom of the pipe bell and the void replaced to within six (6) inches of the pipe with the stabilizer material.

The normal trench depth shall be a minimum of six (6) inches lower than the bottom of the pipe bell, unless an additional bedding thickness is called for on the drawings. Where pipe collars, bells, or flanges protrude in excess of six (6) inches from the pipe barrel, the Contractor shall hand excavate in these areas sufficiently to allow the pipe bell to rest uniformly on the bedding material. Pipe being supported by the collars, bells or flanges on natural soils will not be allowed. Unauthorized and excessive trench depths shall be filled to bedding subgrade with foundation stabilizer material at the Contractor's expense. Reuse of trench excavated soils will not be permitted in the trench until the pipe and bedding materials have been properly installed.

20.3.5 Trench Width

The allowable trench width, regardless of the type of soil encountered, the depth of excavation or method of bedding densification, shall not exceed the outside diameter of the pipe barrel plus twenty-four (24) inches or be less than the outside diameter of the pipe barrel, plus twelve (12) inches when measured at any point below the top of the pipe bell, flange or collar.

When necessary to minimize sliding or caving of the trench, it will be permissible to slope the banks from the surface to an elevation twelve (12) inches above the top of the bells, flanges or collars. Trench banks below said elevation shall be maintained in a vertical plane as stated herein above, until the pipe has been bedded and backfilled to an elevation of twelve (12) inches above the pipe barrel. Excavated material shall be piled a sufficient distance from the trench banks to avoid sliding or caving of the trench walls.

20.3.6 Unauthorized Trench Width

Where the width of the lower portion of the trench exceeds the maximum width herein above stated, the Contractor, at his expense, shall furnish and install special pipe embedment or concrete encasement to protect the pipe from the additional loading. The type and quantities of special pipe embedment shall be determined by the Engineer, based on a pipe strength equal to the three edge bearing ultimate strength stipulated for a non-reinforced rigid pipe of comparable diameter, saturated backfill weighing 120 pounds per cubic foot and allowance for truck or other live loads where applicable.

20.3.7 Trench Supports

Whenever the sides of the trench will not stand vertically and within the limits herein above specified during the pipe installation, the Contractor shall install sheeting and shoring to prevent any excessive widening or sloughing. Where excavations are made under severe

water conditions, the Engineer, at his discretion, may require the Contractor to use approved engineered shoring such as a piling instead of sheeting.

20.3.8 Surplus Excavated Material

All waste and surplus excavated materials shall be removed from the project and disposed of by the Contractor.

20.3.9 Traffic Plate Bridging

The Contractor shall secure approval, in advance, from the Engineer for any steel plate bridges proposed by it for public use. Transverse or longitudinal cuts in the right-of-way that cannot be properly completed within a workday shall be protected by structural steel plate bridging in such a way as to preserve unobstructed traffic flow. All structural steel plates placed over surface voids, such as trenches and other areas to be protected in the public right-of-way shall conform to the following:

All unrestored voids, trenches, holes, excavations, etc., that are in the pedestrian or traveled way shall be protected through the use of adequately designed barricades and structural steel plates that will support legal vehicle loads.

Structural steel plate bridging shall be designed for HS-20 truck loading per CDOT. See Trench Width/Minimum Plate Thickness table below. Steel plates used for bridging must extend a minimum of 12 inches beyond the edges of the trench. All plates shall provide complete coverage to prevent any person, bicycle, motorcycle or motor vehicle from being endangered due to plate movement causing separations or gaps. Plates shall be installed with the plate laid in reasonably flat plane and all vertical edges transitioned with asphaltic cold-mix or other acceptable ramping device(s) acceptable to the Engineer. Structural steel plates shall have a skid-resistant surface. Fine graded asphalt concrete shall be compacted to form ramps with a maximum slope of eight and one-half percent (8.5%) and a minimum of 12-inches taper to cover all edges of the steel plates.

When steel plates are removed, any damage to the pavement shall be repaired with either graded fines of asphalt concrete mix, or equivalent material satisfactory to the Engineer. The Contractor shall be responsible for maintenance of the structural steel bridging plates, shoring and asphalt concrete ramps. The trench shall be adequately shored to support the bridging and traffic loads. Steel plate bridging shall be secured against movement or displacement by using adjustable cleats, shims, welding, or other devices, and shall be installed in a manner that will minimize noise.

When steel plates are placed within the public right of way the Contractor's name and twenty-four (24) hour phone number shall be visible, legible and permanently affixed on each plate or the Contractor shall erect sign(s) in the immediate area of the trench plate(s) identifying the Contractor's name with a twenty-four (24) hour phone number. The minimum height of letters and numbers shall be 2 inches. The Contractor shall immediately mobilize necessary personnel and equipment after being notified by the Engineer of the City's emergency service personnel of a repair need. This includes, but is not limited to, plate anchors, cold-mix, and asphalt concrete to transition/ramp from the existing roadway or sidewalk to the plate surface and back down. Failure to respond to the emergency request within two hours will be ground for City repairs that will be invoiced at actual cost including overhead or \$500 per incident, whichever is greater. Lack of Contractor conformance will be automatic grounds for suspension of their permit/contract.

The following table shows the required minimal thickness of steel plate bridging required for a given trench width:

Table 1 – Trench Width/Minimum Plate Thickness

| <u>Trench Width</u> | <u>Minimum Plate Thickness</u> |
|---------------------|--------------------------------|
| Less than 12" | 1/2" |
| 12"-23" | 3/4" |
| 24"-35" | 7/8" |
| 36"-47" | 1" |
| 48"-60" | 1-1/4" |

Note: For spans greater than 60", a structural design shall be prepared by a Colorado registered civil engineer and approved by the Engineer. A Rough Road sign with black lettering on an orange background shall be used in advance of structural steel plate bridging.

20.4 BEDDING

All pipe, regardless of type or diameter, shall be installed on sufficient bedding material so as to provide a minimum of six (6) inches separation between the subsoil and the pipe barrel, after consolidation. See Bedding Material Paragraph 20.2.2 for types of acceptable bedding material and Standard Drawing SS-1 and W-1 for pipe bedding and backfill limits.

20.4.1 Fully Embedded Pipe

Pipe twenty-four (24) inches and smaller in diameter, regardless of type, and all non-reinforced concrete, clay, asbestos cement, ductile iron, cast iron, CSP, PVC, steel, flexible and profile wall pipes, regardless of diameter, shall be enveloped with consolidated bedding material from six (6) inches below the pipe barrel, between the trench banks and to a cover above the pipe of not less than twelve (12) inches. French or perforated underdrains shall be fully embedded in the pipe foundation stabilizer material to six (6) inches each side of the underdrain pipe.

20.4.2 Partially Embedded Pipe

Prestressed concrete cylinder (PCCP) and reinforced concrete (RCP) pipes twenty-seven (27) inch and larger in diameter, need only be granularly embedded between six (6) inches below the pipe barrel to pipe springline and horizontally to adjacent trench walls.

20.4.3 Bedding Installation

Pipe bedding material shall be placed in the trench to a loose depth of seven (7) inches and then fine graded along centerline of the pipe barrel to a thickness of six (6) inches. Special precautions shall be taken to remove sufficient bedding material at the point where the pipe bell, collar or flange falls, insuring a uniform bearing of the pipe barrel throughout its length.

After the pipe is properly joined and set to line and grade, a second loose lift of bedding material, not to exceed eight (8) inches, shall be placed along each side of the pipe and then consolidated by tamping or vibration until uniform support under the pipe haunch is obtained. Additional bedding shall be carefully placed to the limits specified and then consolidated by a

combination of tamping and vibrating. At all times special precautions shall be taken to prevent displacement of or damage to the pipe.

20.4.4 Densification of Bedding

Bedding material shall be compacted to 70% relative density as determined by ASTM D2049.

20.5 BACKFILL

Backfill of the trench, after the bedding material is in place and consolidated, shall be conducted in a manner to prevent damage to the pipe or its coating. When backfilling over a flexible conduit, compaction must be controlled to the extent that elongation along any axis of the pipe shall not exceed two (2) percent for steel or five (5) percent for plastic conduits.

Backfill shall be uniformly graded and free of all frozen material and all clods, rocks, stones, etc. greater than six (6) inches in diameter. A vibratory roller or compacting hammer equipment shall not be used closer than eighteen (18) inches from rigid pipe or thirty-six (36) inches from flexible pipe.

Concrete placed in a trench to encase the pipe shall be covered with not more than thirty-six (36) inches of loosely placed backfill material and the concrete then allowed to cure for a period of five (5) days before the trench backfill is consolidated by one of the methods hereinafter described.

In areas where the trench has been sheeted, for whatever reasons, extra precautions shall be taken during backfill to solidly fill all cavities behind the sheeting when it is being abandoned in place, or to solidly fill all cavities in or adjoining the trench as the sheeting is being removed.

20.5.1 Generally Unacceptable Soils for Backfill

Soils which possess a Plasticity Index of twenty (20) or greater shall be disposed of and replaced with a material which meets the requirements of an acceptable or select backfill material, as specified in the Materials portion of this section of the Specifications, Section 20.2.3. In general, unacceptable backfill materials may only be used for backfilling pipelines which cross open fields and which will not be subjected to heavy loading for a period of two (2) years.

If approved in writing by the Engineer, backfilling with this unacceptable backfill material shall be accomplished by placing the material in loose lifts, not to exceed three (3) feet over the bedded pipe, followed by longitudinal rolling of each lift with a motor patrol, loaded truck or other rubber tired equipment until the full width of the backfill in the trench shall have been consolidated equally. Upon completion of the backfilling and compaction within the trench limits, the top of the trench shall be graded and mounded sufficiently to allow for subsidence to the level of the adjacent ground surface.

Should the total cover over the pipe be less than three (3) feet, longitudinal rolling will not be allowed.

Backfill of this nature shall not be performed in easements across lands not owned by the City unless specific authorization in writing has been obtained from the property owners involved, which allows backfilling in the manner herein above described and which also absolves the City of all responsibility for subsidence.

20.5.2 Flowable Fill/Flowable Fly Ash Backfill

No flowable fly ash backfill shall be used to backfill abutments. Compaction of flowable fill/flowable fly ash backfill will not be required if material meeting the requirements in Section 20.2.4 is used.

The maximum layer thickness for flowable fly ash backfill shall be three feet. Additional layers shall not be placed until the flowable fly ash backfill has lost sufficient moisture to be walked on without indenting more than two inches. Damage resulting from placing flowable fly ash backfill in layers that are too thick or from not allowing sufficient time between placement of layers shall be removed and replaced.

20.5.3 Trenches in Streets

Trenches that are over 40 feet long within the limits of existing public thoroughfares and rights-of-way shall be backfilled with granular soils at optimum moisture content placed in the manner hereinafter described and shall meet the requirements set forth under the materials portion of this specification for "select" backfill material. Backfill for all trenches in new streets shall meet the requirements set forth under the materials portion of this specification for "acceptable" backfill material and shall be placed in the manner hereinafter described.

Backfill over the consolidated bedding shall be placed in loose twelve (12) inch lifts and each lift thoroughly consolidated by wheel rolling, tamping, surface or internal vibrating, or by other suitable compaction equipment acceptable to the City representative, until the relative compaction, when determined in accordance with AASHTO T-99 or T-180, is equal or greater than the minimum value hereinafter shown for the various classes of soil and type of compaction. Layer thickness shall be reduced if the compaction equipment and compaction effort does not provide the required degree of compaction. Layer thickness may be increased only when sufficient compaction tests are provided to the Engineer showing that a piece of equipment can compact to a depth greater than twelve (12) inches. Compacted backfill shall be placed to minimum depth of thirty six (36) inches over the top of the pipe before a vibratory roller or hydro hammer can be used over the pipe.

| Soil Classification (AASHTO M-145) | Minimum Relative Compaction (percent) | | Moisture % of optimum |
|---------------------------------------|---------------------------------------|--------------|--------------------------|
| | AASHTO T-99 | AASHTO T-180 | |
| A-1 through A-5 | 100 | 95 | -3, +3 |
| A-6 and A-7 | 95 | n/a | -1, +3 |

Backfilling and compacting in lifts shall continue until the trench has been filled or the elevation of the subgrade for base course and/or asphalt has been reached.

Squeegee bedding shall be consolidated by tamping, vibrating or a combination thereof, to 70% relative density as determined by ASTM D2049.

Consolidation shall be obtained by the use of hand tampers having a minimum weight of twenty (20) pounds and a facial area in excess of twenty-four (24) square inches or by other proposed means of compaction acceptable to the City representative. Hydro hammers or vibratory rollers shall not be used prior to placing a three (3) foot loose lift of acceptable backfill material above the twelve (12) inches of prior compacted bedding material. In cases where compacted bedding is required only to pipe springline, backfill material shall be compacted in six (6) inch lifts from springline to a depth of twelve (12) inches over the pipe

crown prior to placing a three (3) foot loose lift of backfill, in preparation for vibratory rolling or hydro hammering. Large self powered or tractor drawn compactors shall not be used within thirty six (36) inches of any pipe crown or sidewalls.

20.5.4 Trenches in Fields and All Other Areas

Trenches shall be backfilled with the native material and compacted to a minimum 90 percent of maximum standard density in accordance with AASHTO T-99.

20.5.5 Vibrating and Jetting

Consolidation of backfill by vibrating and jetting will not be allowed in any trenches.

20.5.6 Compaction Testing

A minimum of one moisture density compaction test per every 250 linear feet of trench and at every two (2) feet of depth is required for all pipeline and utility trenches. Compaction tests for every other (1 of every 2) water and sanitary service line trench excavated is also required. Twenty-five (25) percent of the service line tests must be taken at the back of the curb line. A minimum of one test will be required within one (1) foot of each valve box and manhole. Tests will be performed at the City's expense on City projects. On private development projects, compaction testing shall be performed by private engineering or geotechnical firms at the Contractor/Developer's expense and submitted to the Engineer along with a written declaration letter signed by a Professional Engineer on behalf of the private engineering or geotechnical firm that the test results and frequency were in general compliance with the plans and specifications for review and approval prior to any surfacing of streets. Compaction tests must be performed by a City approved Geotechnical Engineer working under the direct supervision of or licensed as a Professional Engineer in the State of Colorado. Testing intervals may be increased at the discretion of the Engineer. Results shall report densities (maximum dry and relative) to nearest 0.1 lb/cu. ft., moisture content (optimum and in place) to nearest 0.1%, and compaction (relative and required) to nearest 0.5%. In questionable areas of backfill where initial tests show the compaction does not meet the compaction standards specified in Section 20.5.3 of this section of the Specifications, additional tests may be required. Additional testing may also be required if significant moisture or freezing conditions have affected the previously consolidated backfill material before permanent asphalt surfacing has been placed. The successful passing of a compaction test or tests does not constitute acceptance of the work or materials represented by the tests or any portion of the work or materials. The Contractor is solely responsible for quality control of his work. The work will only be accepted by the City upon completion and after expiration of the two year warranty period required in the "Engineering Code of Standards and Specifications for the Design and Construction of Public Improvements".

20.5.7 Utility Service Line Backfill

Water and sewer service stubs being installed in previously surfaced streets shall be bedded with materials as described in this section of the Specifications and backfilled with Flowable Fill or Flowable Fly Ash Backfill only.

20.5.8 Street Maintenance During Construction

The maximum amount of open trench ahead of the installed pipe shall not exceed one hundred (100) linear feet. At the end of each shift, or shifts shortened for cause, the pipe trench shall be backfilled, compacted, surface graded and the trench filled to within ten (10) lineal feet of the excavated trench face. However, any liability resulting from trenches left open or improperly backfilled and maintained shall be at the Contractors expense.

During the progress of the work backfilled trenches shall be maintained free of chuckholes, ruts, loose rocks and dust. Daily the Contractor shall level to grade non-paved surfaces and spray thereon dust palatives or water in sufficient quantity to control dust, until such time as the trench is permanently asphalt surfaced. Every 7-10 calendar days maximum all unpaved trenches on the project shall be re-excavated to a depth of six (6) inches below finish grade and a fresh layer of road base or select backfill material shall be placed and compacted to top off the trench and provide a smooth riding surface until permanent asphalt is placed.

20.5.9 Maintenance of Backfill and Surface Warranty

Backfill shall be maintained in a satisfactory condition and all areas showing signs of settlement shall be filled and maintained for a period of two (2) years following the date of preliminary acceptance for all work performed. When the developer or Contractor is notified by the City that any backfill is hazardous, he shall correct such hazardous condition at once.

20.5.10 Housekeeping Restoration and Clean Up

See Section 5 of these Specifications.

20.6 SURFACE RESTORATION

20.6.1 Surface Restoration

Paving, curb, gutters, sidewalk, improved surfaces, or other street improvements removed, damaged or destroyed during construction shall be replaced to the same elevation and alignment, equal to and consistent with the undisturbed portions of the improvements existing prior to trench excavation. Restoration work shall be completed within seven (7) calendar days after trench backfill is complete, weather permitting. Subgrade for all restored surfaces shall be thoroughly compacted by mechanical or hand tampers weighing not less than twenty (20) pounds, by vibratory rollers or by other proposed means of compaction acceptable to the Engineer.

When inclement weather threatens, Contractor shall only excavate and place asphalt in areas where sufficient lifts of asphalt can be placed prior to the inclement weather to bring the level of the patch to the level of the existing asphalt surface. Portions shall not be left on any trench patch at the end of the working day if the depth of the patch is lower than the existing street surface. Excavated areas that have not been patched to the level of the existing surface prior to sudden inclement weather shall be filled in with CDOT Class 6 road base and re-excavated, leveled, re-compacted and prepared for patching when weather conditions are again suitable to place asphalt.

Trench patching shall be completed by straightening the asphalt edges along the trench , truing to a vertical plane and then asphaltic priming the edges. Subgrade shall be leveled and recompacted. The void thus created shall then be filled with two (2) or three (3) compacted lifts of Colorado Department of Transportation (CDOT) Grading S (bottom lift(s)) and SX (top 2" lift) bituminous asphaltic surfacing material totaling six (6) inches in depth or matching existing asphalt depth, whichever is greater. Maximum compacted lift depth shall be four (4) inches. Minimum compacted lift depth shall be two (2) inches. Top two (2) inch lift shall use CDOT Grading SX bituminous asphaltic surfacing material.

In the event hot mix bituminous material is not available during winter months, the Contractor shall install and maintain a temporary two (2) inch layer of cold mix asphalt atop the trench where required by the City Inspector. As soon as the hot mix plants are again producing CDOT Grading S and SX the Contractor shall re-excavate the trench and install the minimum

six (6) inch layer of bituminous mix in the manner herein above outlined. No more than 1,300 feet of trench on any existing street shall remain open without permanent asphalt surfacing.

The following trench milling requirement shall not apply to City projects unless otherwise stated in the Special Conditions for the City project. Milling and overlay of street cuts on City projects will be completed as part of the City's annual street milling and overlay project unless the street or overlay on the street to be cut on a City project is less than five (5) years old. If this is the case, then the following milling requirement shall apply to all street cuts, including City projects. Any streets or overlays on streets that are less than five (5) years old shall be noted in the Special Conditions on City projects.

For all street cuts, permanent asphalt surface restoration shall be completed after trench patching as follows. For all street cuts on streets less than five (5) years old or overlays on streets less than five (5) years old this work shall be completed within seven (7) days after the backfill and patching work is complete.

The street in the area of the trench or hole shall be milled to a two (2) inch depth for a width of twelve (12) feet, being centered along the length of the trench or hole. If the trench or hole width is greater than six (6) feet, the milling width will be the maximum trench width plus six (6) feet. The milling shall extend ten (10) feet beyond the beginning and the end of the trench or hole. The resulting milled surface shall be overlaid immediately after the milling with a two (2) inch mat of Grading SX asphalt in a manner to form a smooth and continuous street surface. If the street or overlay on that street is less than five (5) years old, the Contractor shall complete the trench patching and this work within seven (7) calendar days of backfill. In all cases, the longitudinal limits of restoration will extend past the street cut by a minimum of ten (10) feet in each direction. The trench patch may be left down two (2) inches below finished grade to avoid having to mill freshly placed asphalt if the milling and overlay can be and is completed on the same working day as the trench patch.

In lieu of the above requirements, the Contractor may pay a degradation fee at the time of Public Improvements Permit application for all streets or overlays on streets older than five (5) years.

The milling and overlay work will then be completed by the City at a later date. The degradation fee option shall not be allowed for City projects.

Immediately following installation of the temporary or permanent asphalt surfacing, the entire width of the asphalt surface and concrete gutters, if in place, shall be cleaned of all debris, power broomed and maintained free of rock and debris throughout the construction period.